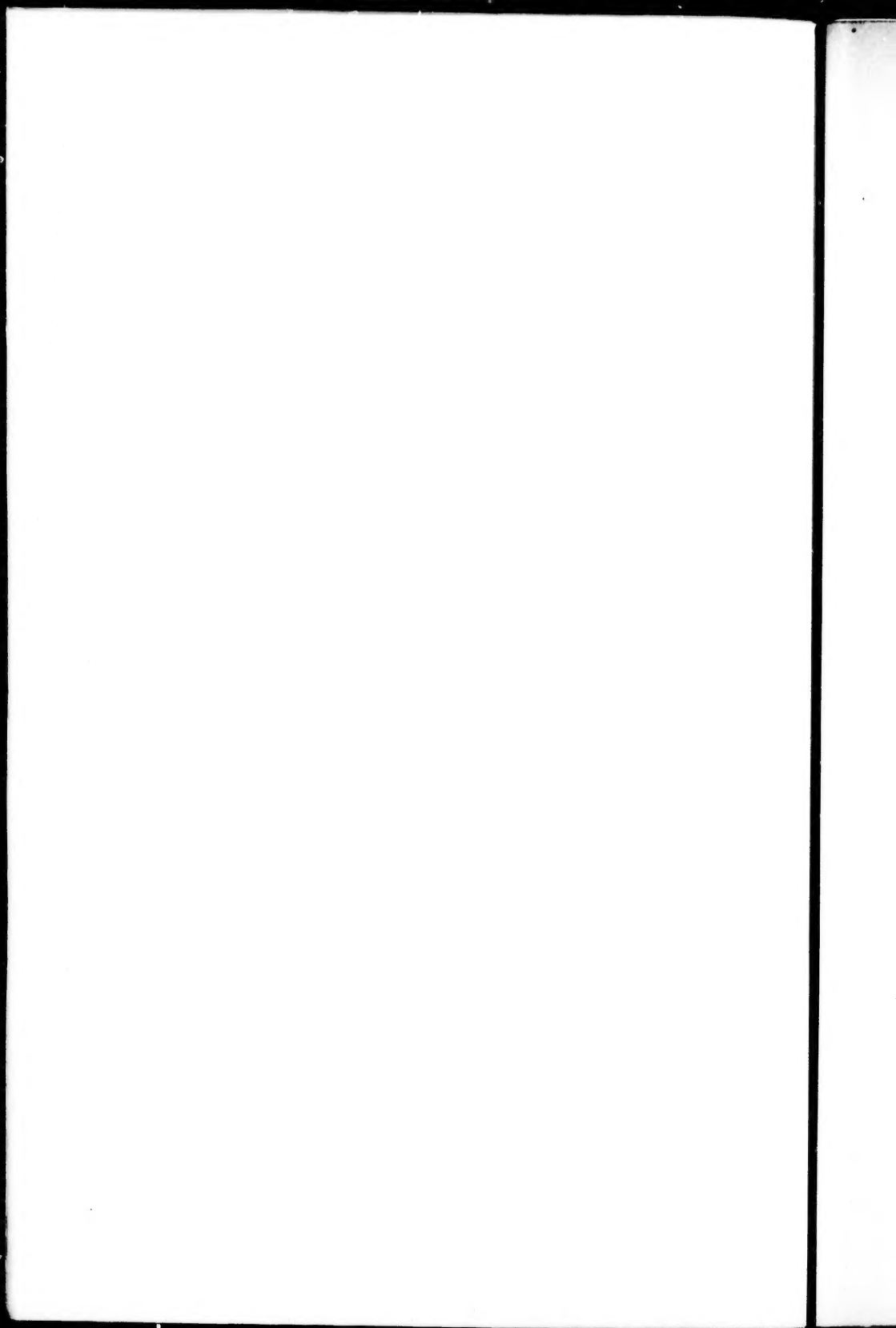




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GLACIAL FEATURES OF PARTS OF THE YUKON AND MACKENZIE BASINS.

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The following notes, which I have endeavored to make as brief as possible, on the more salient glacial features of parts of the Yukon and Mackenzie basins, were obtained while on a hasty geological reconnaissance in the north in the summers of 1887 and 1888. The route travelled on this occasion followed the main water-courses of the country. Starting from the mouth of Dense river, west of the Rocky Mountains, in lat. 60° N., the Liard was followed in its stormy course eastward through the Rockies to its junction with the Mackenzie in the low lands east of this range. From Fort Simpson, at the mouth of the Liard, I ascended the Mackenzie and its continuation, Slave river, to Fort Smith, and then, turning northward, descended Slave river

to Great Slave lake, coasted along this lake to its outlet, and then descended the Mackenzie river through its whole length to the head of its delta at the mouth of Peel river, lat. $67^{\circ} 45' N$. From this point the Rocky Mountains, here about four thousand feet in height, were recrossed by the Peel river portage to the head waters of the Porcupine, and the latter followed westward, through its long ramparts, to its junction with the Yukon. Then bending again to the south, the Yukon was ascended to old Fort Selkirk, where connection was made with the line of exploration traversed in the previous summer by Dr. G. M. Dawson. Of the rivers mentioned, the Mackenzie only had been previously examined by a geologist, and that only in a cursory manner and before the subject of glaciation had received much attention.

We shall commence the descriptive journey at Great Slave lake. This lake is situated upon the western margin of the Archean axis, and had originally the form of a great cross, with one arm penetrating the crystalline schists, while two others stretched north and south along the junction of these with the newer sedimentaries, and the fourth extended itself over the flat-lying Devonian to the west. The southern arm has now completely disappeared, and its bed is filled with a great alluvial deposit of clays, false-bedded sands, and fine gravels, which have been brought down by Slave river and through which its tortuous channel now winds. Not satisfied with burying the southern arm, this river is now pushing its delta far out to sea, and threatens at no distant day to inflict a similar fate on the whole eastern portion of the lake. The time spent on Great Slave lake was not sufficient to enable me to form a theory as to its origin which would have much value, but its peculiar shape, the great depth of the Archean portion taken in connection with the comparatively low elevation of the country which surrounds it, and the precipitous cliffs which border the shores of this part in so many places, seem inexplicable by glacial agencies. It is possible, however, that the western portion, which is much shallower and has low, shelving shores, may have been excavated in part or altogether by a glacier forcing its way out of a previously formed basin to the east. No very distinct groovings or striae were observed around the lake, but the hummocks of the *roches moutonnées* gneissic surface of the country in the vicinity of Fort Rae have their major axes generally orientated in a direction about $S. 30^{\circ} W.$, or diagonally across the great northern arm of the lake on which the fort is situated. Well defined glacial hummocks carved out of massive dolomites were observed in one place on the western arm running in a westerly direction, or almost parallel to the general course of this portion of the lake.

Great Slave lake, like the other great lakes to the south lying along the Archean boundary, affords proof in the terraces surrounding it of former higher levels of its waters. Fragments of two lines of terraces were noticed in a number of places around the western arm of the lake. The greatest elevation of these did not, however, exceed 30 feet above the present surface of the water.

Hay river, which enters great Slave lake near its western end and drains the country to the southwest, has evidently had a history somewhat similar to that of the Niagara; but it has not yet been thoroughly explored. In its lower part its valley is carved out of a soft shaly terrane holding Hamilton fossils. Fifty miles above its mouth a heavy band of cream-colored limestone overlying the shales crosses the river, and a striking change is at once observed in the aspect of the valley. As we advance, the valley contracts and becomes a gorge, so deep and narrow that its precipitous walls, buttressed below by an embankment of fallen fragments, almost appear to overhang the stream, while the river, reduced in width in some parts to 100 feet, dashes

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along its boulder-filled channel with bewildering impetuosity. At several points small side streams fling themselves over the brow of the unworn cliffs and curve gracefully down into the stream beneath. Six miles above its mouth the gorge is interrupted by a fall 50 feet in height, and a mile further up is closed completely by a fall of 100 feet. Above the falls the river has failed to produce more than a feeble impression on the hard limestone beds which floor the surrounding country, and loses its valley almost altogether.

The Hay river falls owe their origin to precisely the same cause as that which produces the famous falls at Niagara, viz., the superposition of hard limestone on soft shales, and the consequent undermining and destruction of the former effected by the rapid erosion and removal of the supporting beds. It is interesting to find that the rate of retrocession of the two falls, measured by the length of their gorges, has been almost precisely the same. The quantity of the work done by the two streams cannot, however, be regarded as much more than a coincidence, as the factors in the two cases are entirely different. The volume of water which falls over the precipice at Niagara is ten-fold greater than that carried by Hay river, while its erosive power is relatively less on account of its greater purity. Besides Hay river, a number of streams which join the Mackenzie from the south and southwest in the first 100 miles of its course are interrupted by falls and heavy rapids, all of which probably date from the glacial period.

Proceeding down the Mackenzie from Great Slave lake, alluvial clays are noticed for some miles, and then a boulder clay, scarcely distinguishable in character from the same formation as developed in eastern Canada 3,000 miles distant, makes its appearance. It occurs here as a light yellowish, compact, arenaceous clay filled with rounded Archean boulders and, as elsewhere, showing only faint signs of stratification. It is traceable in numerous exposures as far as the mouth of the Liard, which joins the Mackenzie 150 miles from its head.

The Liard which joins the Mackenzie from the west, affords an excellent cross-section of the glacial beds covering the country between the latter river and the mountains. These do not, however, present much variety. Heavy sections of boulder clay resting on the Devonian limestones occur along the valley for the first 50 miles, and then sink beneath the surface; and in the next reach of 50 or 60 miles the river winds through one of those filled-up preglacial depressions which are so frequently met with on the area of the Great Plains. In this the ordinary lake deposits only are seen. West of this basin the Cretaceous shales, which have now replaced the Devonian limestones, rise to the surface but are capped with stratified shales, sands, and gravels only, the boulder clay having disappeared. Glacial erratics, on the other hand, extend far beyond the limits of the boulder clay itself, and are found in some abundance as far east as the eastern edge of the plateau country, which in this latitude borders the foothills of the Rocky Mountains. They were also found on the flanks of a mountain situated opposite Fort Liard, in lat. $60^{\circ} 15' N.$, long. $123^{\circ} W.$, at a height of 1,500 feet above the surface of the surrounding country, or about 2,300 feet above the sea.

Returning to the Mackenzie and continuing on our way down it, we find boulder clay resting on the surface of the rocks and filling up irregularities in the old preglacial surface as far north as the head of its delta in latitude $67^{\circ} 45' N.$, and this notwithstanding the fact that less than 100 miles below the mouth of the Liard the Mackenzie enters the flanking ranges of the Rocky Mountains; and for the next 500 or 600 miles its valley is partially guarded on the east by ranges of mountains, some of which ex-

ceed 4,000 feet in height. The boulder clay or till of the Mackenzie valley, although mostly of the ordinary type, presents some variations. For many miles above Bear river it is exceedingly dark in color and, with the exception of one layer at its base, is almost destitute of boulders. It has a thickness here of over 250 feet. In other places it exhibits an imperfect stratification, and it frequently holds irregular shaped inclusions of a lead-gray clay, some of which are distinctly bedded.

The only evidence of an interglacial period observed was the discovery in one place of an intercalation of stratified sands and gravels dividing the boulder clay into upper and lower parts. This might, however, be due to a purely local cause.

The boulder clay throughout the greater part of the valley is overlain by heavy deposits of stratified sands, clays, and gravels, and is underlain by a gravel formation somewhat similar to that which occurs in the same relative position on the plains of Alberta and Assiniboia, and which I have elsewhere called the Saskatchewan gravels; from which, however, it differs in containing a larger proportion of Laurentian pebbles.

The few facts observed in regard to the direction of the ice flow in the Mackenzie valley support the theory of Dr. Dawson as to its northerly movement. In the western part of Great Slave lake the direction of the ice current, as previously stated, was due west. Five degrees further north, well marked glacial striae trending N. 65° W. were found crossing the summit of Roche Carajon. This rock, which must have been completely submerged, rises to a height of 1,000 feet above the surface of the river. Important evidence on the same point is also afforded by the fact that the till near the lower ramparts of the Mackenzie is in approximately the same latitude as the northern boundary of the Archean area to the east, and the gneiss; boulders which it contains must have travelled either directly west or northwest in order to reach their present situation.

The facts adduced above allow the inference that the ice from the Archean gathering grounds to the east poured westward through the gaps and passes in the eastern flanking ranges of the Rocky Mountains until it reached the barrier formed by the main axial range, when, being unable to pass this, it was deflected to the northwest in a stream from 1,500 to 2,000 feet deep down the valley of the Mackenzie and thence out to sea.

Leaving the Mackenzie for the Yukon, we climb and cross over a couple of terraces, the higher of which has an elevation of 500 feet above the river or about 600 feet above the sea, and then on this route leave all traces of the glacial age behind, although a few miles further north erratics are found fully 1,000 feet higher. In descending the mountains on the west we follow a branch of Rat river through a wild cañon cut out of flat-lying sandstones and quartzites, from the mouth of which a level terrace, with fragments of a higher one resting on it in places, stretches west to Rat river. These terraces are much higher than those on the eastern side, and have an elevation of 1,500 to 1,700 feet above the sea. Proceeding down Rat river to the Porcupine, and down the latter through its ramparts, sands, gravels, and silts are found resting on the country rocks, but no boulder clay nor glacial erratics were anywhere seen. Some distance below the ramparts the valley of the Porcupine widens, and from that on to its mouth it serpentine through a low alluvial plain elevated only a few feet above the surface of the river and evidently representing a filled-up lake basin or former wide dilatation of the river channel. Turning up the Yukon from the mouth of the Porcupine, this river splits up into innumerable channels and, spreading out in places to a width of eight or ten miles, cuts for 75 miles through the same alluvial formation. Above this the valley becomes more contracted,

and occasionally, for the next 200 miles, sands, silts, and gravels similar to those on the Porcupine floor its bottom. Approaching the Stewart river, wide gravel terraces from 30 to 100 feet high border the river and recur at intervals all the way to the Rink rapids on Lewes river, below which point the boulder clay, which has not been seen since leaving the Mackenzie, again makes its appearance. Above this, ice groovings and scorings and all the other well-known marks of glaciation are everywhere evident. I had no opportunity of examining the plateau bordering the Yukon; but, judging simply from the records of the ice age which the valley itself affords, it would appear that the glacier which undoubtedly filled the upper part of the valley of the Lewes and moved northwards did not descend below a point about 50 miles above the mouth of the Pelly, or lat. $62^{\circ} 50' N.$ Below this the deposits indicate a flooded valley, but nothing else.

Before closing this paper I should like to draw attention to a fact which may have some bearing on the non-glaciated condition of part of Alaska and the adjacent portion of the North West territory of Canada, viz., that glaciers are unknown in the Rocky Mountains north of the headwaters of the Athabasca, or about lat. $54^{\circ} N.$ North of this occasional patches of snow survive the summer in sheltered nooks, but even these decrease in frequency with increasing latitude; and on the Peel river portage, in lat. $67^{\circ} 30' N.$, the snow had entirely disappeared before the middle of July. Also, in descending the Porcupine and ascending the Yukon, no snow was seen until far up the Lewes, and no glaciers until the head waters of this stream were reached. It follows from this that climatic changes which would extend the present glaciers of the Bow and Saskatchewan far down their valleys might have little or no effect in imposing glacial conditions on this more northern region.

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